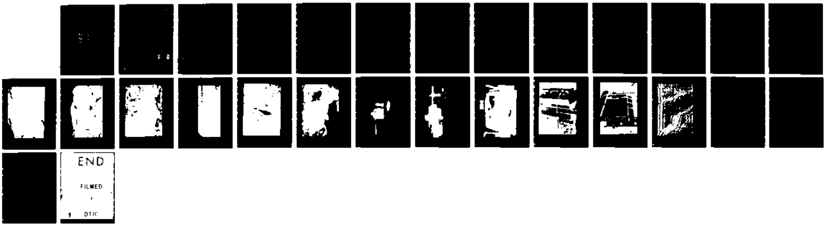
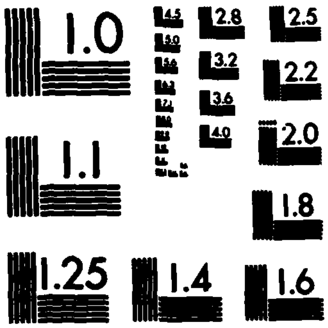
AD-A123 161 INVESTIGATION AND ANALYSIS - GROUND SUBSIDENCE SHEMYA AIR FORCE STATION ALASKA(U) AIR FORCE CIVIL ENGINEERING CENTER TYNDALL AFB FL R BENZINGER JUL 74 AFCEC-ER-74-3 1/1

UNCLASSIFIED F/G 8/7 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ENGINEERING REPORT AFCEC-ER-74-3
This report is not to be used in whole or in part for advertising or sales promotion purposes.

INVESTIGATION AND ANALYSIS - GROUND SUBSIDENCE, SHEMYA AIR FORCE STATION, ALASKA

RICHARD BENZINGER JR., Capt, USAF

AIR FORCE CIVIL ENGINEERING CENTER

JULY 1974

AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
TYNDALL AIR FORCE BASE, FLORIDA

ER 74-3

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE ENGINEERING AND SERVICES CENTER
TYNDALL AIR FORCE BASE, FLORIDA 32403

28 Dec 1982

MEMORANDUM FOR: DTIC-DDAB

Mr Schregengost:

Per your request. Sorry but this is the best copy I could find. Hope it'll satisfy the needs of DTIC and the ultimate user.

If I can be of further assistance, please call.

Andrew D. Poulis
Chief Technical Library

Commander

ABSTRACT

This report covers a discussion of geological information, construction history, conditions encountered, and equipment utilized in studying the ground subsidence problem at Shemya Air Force Station, Alaska. The report also contains conclusions based on the data acquired.

FORWARD

This report was prepared by the Directorate of Laboratories, Air Force Civil Engineering Center. It was initiated under the direction of HQ USAF/PREE based on a request from HQ AAC and CINCSAC as a result of an unexplained ground subsidence in the vicinity of an aircraft parking apron at Shemya AFS, Alaska. Due to the remote location of the island and the nonavailability of conventional drilling equipment, the portable Electromagnetic Subsurface Profiling equipment developed by Geophysical Survey Systems, Inc., was selected as the most appropriate tool for the study.

AIR FORCE CIVIL ENGINEERING CENTER
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
TYNDALL AIR FORCE BASE, FLORIDA

ENGINEERING REPORT
AFCEC ER 74-3
JULY 1974

DIRECTORATE OF LABORATORIES
AIR FORCE CIVIL ENGINEERING
CENTER

INVESTIGATION AND ANALYSIS - GROUND SUBSIDENCE, SHEMYA AIR FORCE STATION, ALASKA

I. PURPOSE: Under the direction of HQ USAF/OREE at the request of HQ AAC and CINCSAC this study was conducted to ascertain the causes of the ground subsidence and to locate any existing voids under airfield pavements in an attempt to determine if future subsidences would occur, and if so, where.

II. BACKGROUND: Shemya Air Force Station is located on the Island of Shemya, one of the three islands comprising the Semichi Group. It is located near the western end of the Aleutian chain of islands. There is very little printed data available concerning its geology. The following is an exerpt from Geological Survey Bulletin 1028U - Department of the Interior. This Bulletin is dated 1971 but is based on explorations conducted in early to mid 1940's.

"Geology of Near Islands, Alaska

SHEMYA ISLAND

STRATIGRAPHY

The basement rocks are a series of argillitic, tuffaceous, and conglomeratic rocks in the western half of the island. These rocks may be middle Tertiary in age and roughly equivalent to the Chuniksak Formation of Attu. Probably younger is a layered sequence of bedded pyroclastic rocks found chiefly in the northeastern part of the island. These pyroclastic rocks dip gently northwestward and are cut by basalt pipes which may be feeders for some of the pyroclastics. Youngest of the bedrock units are the feldspar and hornblende porphyry instrusives that crop out along the northeast and southeast shores and locally inland.

The whole bedrock sequence of Shemya was planed off, presumably by marine erosion, in late Tertiary or early Quatermary time, then uplifted and tilted slightly to the south. Only relatively thin layers of subsequently deposited unconsolidated materials lie on this platform. These surficial deposits, together with their implicaitons as to recent history

of the island, are discussed more fully by J.P. Schafer in the section "Surficial Geology of the Near islands."

BASEMENT ROCKS

The basement rocks, which are extensively exposed around the shores of the western half of the island, consist mainly of fine-banded argillites, limy argillites, siltsone, graywackes, and conglomerates that dip north to northwest. Silicified and pyritized lava overlain by bedded cherty sediments and graywackes that dip about 50° N occurs at the head of the Alcan Harbor. A quarter of a mile farther north along the shore platform are outcrops of graywacke and pebble conglomerate, that here dip 30° to 60° NW. Intense shatter zones cutting across the platform imply faulting, but displacement is unknown.

Bedded tuffaceous sedimentary rocks crop out at the western tip of the island and along the south coast. At the westernmost point, fine-bedded argillitic rocks that strike N 55° E and dip 65° N overlie conglomerate and coarse tuff. The conglomerate and tuff, which are exposed for about 100 feet along the shore to the southeast, in turn overlie laminated argillitic and tuffaceous rocks containing lime nodules elongated parallel to the bedding. A contact of argillite with a still older conglomerate strikes N. 60° E and dips 30° NW. Locally the rocks are faulted and folded.

Age of the basement rocks - Thin bedded tuffaceous sediments crop out with conglomerate along the shore near Skoot Cove, and a lime nodule from this series furnished the following diatoms, as reported by K.E. Lohman of the US Geological Survey (written commun., Feb 14, 1951):

Actincyclus sp. indet.
Actinoplychus senarius Ehrenberg
Coscinodiscus cf. C. radiatus Ehrenberg
Coscinodiscus cf. C. oculus-iridis Ehrenberg
Endictye robusta (Greville) Hanna and Grant

All these species are marine and have geologic ranges from Miocene to Holocene. Endictya robusta reached its heyday in late Miocene, and because it is also the most abundant diatom in this sample, an age of late Miocene can be tentatively assigned to this sample on this meager evidence.

Farther east along the shore are more conglomerates and tuff-breccias that also dip northward and northwestward. These and the ones previously mentioned contain abundant cobbles and fragments of hornblende-bearing lavas like those in the Massacre Bay and Faneto conglomerates of Attu.

ANDESITIC AND BASALTIC TUFF AND TUFF-BRECCIA

A sequence of bedded andestic and basaltic tuff and tuff-breccia in the northeastern part of Shemya Island is s especially well exposed in the shore platform north of the hospital area. The sequence is in fault contact with the basement rocks on the north shore, but because of its lack of folding and alteration it is regarded as discinctly younger than the basement rocks, possibly late Tertiary or early Quarternary.

The tuff and tuff-breccia are characteristically buff to brown to gray and occur in persistent beds a few inches to several feet thick which dip at angles of less than 20° NW. Hornblende-bearing fragments are common, and abundant phenocrysts of both hornblende and pyroxene are found in some of the breccias. Some beds are light-gray feldspathic sandstones.

HORNBLENDE PORPHYRY

Hornblende dacite porphyry occurs in two areas in the central part of the island. A hornblende-poor dacite porphyry occupies the eastern end of the island and is exposed also in a small quarry in the north-central part and on the north coast.

BASALT PORPHYRY

The tuff and tuff-breccia are cut by a basaltic pipe that is excellently exposed in a roadent in the shore slope near the middle of the north shore, and by another one near the eastern end of the island. The first pipe is probably about 500 feet in diameter, and the second may be only half as large. Both are composed of black fine-grained basaltic rocks with excellent columnar jointing perpendicular to the contacts with the surrounding tuffaceous rocks.

STRUCTURE

The basement bedded rocks in the western part of the island appear to have a consistent northerly or northwesterly dip ranging from 25° to 65°. No fold axes were mapped. The bedded tuff dips more gently but still mostly northwestward. One of the few reverse dips noted was 10° SE on the north shore about in the middle of the shore platform exposure of the bedded tuff.

The jointing in the basement rocks in intense, and in some places the rock is so fractured that during quarrying it breaks easily into fragments small enough for direct use as road metal. Undoubtedly many faults besides those shown on the geologic map are present in the basement rocks.

SEMICHI ISLANDS

Of the three islands in the Semichi group, Shemya and Nizki are low islands, and Alaid is partly low and partly hilly. Only Shemya was visited by members of the field parties, and most of this discussion refers to it. The surface of Shemya is a gently rolling low plateau about 2 miles wide and 4 miles long. It slopes rather uniformly to the southwest and south-southwest, from altitudes of 200-275 feet at the crest of the north shore cliffs down to 25-75 feet along the south shore, at an average rate of about 125 feet per mile. The southwest corner of the island stands above the adjacent sloping surface. The shallow basins and valleys on the island are mostly in a mantle of surficial materials.

Excellent exposures are provided by two deep quarries northwest of the center of Shemya, at an altitude of about 200 feet. In the west quarry the bedrock surface is exposed for a distance of more than 500 feet. Its profile is almost straight; the only conspicuous irregularity is a sag about 3 feet deep at the contact between two rock types. The bedrock surface slopes gently to the southwest and where it has not been shattered by weathering it is sharply knobby and cuspate and has a relief of a foot or less. The knobs and cusps, whose forms are controlled by jointing in the rock, have smoothly worn and locally polished surfaces. This kind of surface, shown at many places on modern WAVE-cut platforms along the present shoreline, is very unlike the rounded stoss-and-lee surfaces cut by glacial erosion. In the west quarry, bedrock is overlain by 3-10 feet of sand and boulder gravel. In the east quarry both the bedrock surface and overlying materials are like those in the west quarry. In the cliffs of the north shore the bedrock surface is less well exposed, but it seems generally similar to that of the quarries.

The bedrock surface of Shemya is certainly a WAVE-cut platform. It is most likely of pre-Wisconsinan age, because a considerable period of stability of sea level must have been required to cut it, and because glacial fill is exposed in many shallow excavations on the higher part of the island. The gently rolling lake-dotted surface of the whole island has a glaciated appearance. A small exposure of the bedrock surface at the west end of the west quarry shows about 1 square yeard of ice-eroded form, different from the WAVE-worn surface indicate that glacial ice moved from west to east. Striations are present also on some of the boulders in the gravel at both quarries.

No explanation of these facts seems completely satisfactory, but the interpretation favored by the writer is as follows. The bedrock platform of Shemya was cut by marine erosion, covered by marine deposits, and then glaciated. The marine deposits were partly removed by glacial erosion, which in at least one place cut into waive-cut bedrock surface. Till

was deposited in some places, principally on the higher part of the island. Outwash sand and gravel were also deposited, covering the one known area of glaciated bedrock surface. This hypothesis requires that where the distinctively WAVE-worn bedrock surface is not glacially eroded, at least the lower part of the overlying sand and gravel must be marine and must have protected that surface from glacial erosion. However, no unconformity was seen in the extensive exposures of sand and gravel to support the idea of separate glacial and marine deposits. At no place could the relationship of the till to the sand and gravel be seen, but the till is inferred to be younger than the supposed marine deposits, and it is certainly younger than the marine planation of the platform.

According to Coats (1956, p. 86), Shemya was not glaciated after the platform was cut by marine abrasion, and the sand a and gravel are ma ine,, perhaps reworked from glacial material. This hypothesis is opposed by the available evidence, which shows that glaciation occurred after marine planation.

Nizki Island and the lowland part of Alaid Island are at altitudes below 200 feet; they resemble Shemya and probably are marine terraces of similar age. The area of 600-foot-high hills at the west end of Alaid must have been a small island when the terrace was cut.

TERRACE CORRELATIONS

Clearly, the different islands, and even different parts of one island, have not had the same history of changes of level, but probably have been affected by local and different crustal movements. Possible groupings of the pre-Wisconsinan terraces may be suggested on the basis of degree of preservation. On the Shemya platform and probably on some of the lower terraces of Attu (as at Mikhail Point) parts of the original marine platforms are preserved under surficial deposits. These terraces are presumably younger than deeply dissected terraces, the original WAVE-cut rock surfaces of which have been entirely destroyed by later erosion. Among these young terraces are the plateau and terraces of Agattu, and probably the high terraces of the north shore of Attu."

(2) The following is an excerpt from a FY75 MCP Project Development Booklet - prepared by HQ AAC.

"<u>Subsoil Conditions</u>

Shemya is a small, low island the highest points of which stand approximately 250' above sea level. The island has the general appearance of a mesa tilted to the west and south. Steep rock bluffs rim the island on the north and east. The ground surface has been moderatly modified by thick accumula-

tions of tundra-type vegetation which has become partly consolidated. The island is predominantly of volcanic origin. The volcanic rocks consist of extrusive lava flows and pyroclastic formations such as basalt, tuft, and agglomerates. Some of these volcanic rock formations are metamorphosed to the extent that the original composition is obscured. At several locations, bodies of syenite rock are found intrusive into volcanic rocks. Variations in the composition and texture of the syenite exposures indicate multiple intrusions emanating from an underlying magma. The intrusion of the syenite bodies into the volcanic rocks have contributed to the metamorphism of some of these rock formations. Rock structure of the island is not known, although there is evidence of tilting and faulting. Permafrost does not exist on the island. Ground water occurs at various places throughout the island."

(3) The two preceding excerpts constitute all of the printed geological data that could be obtained in the Anchorage area. The following agencies were visited:

(a) The State Geologist

(b) The USGS

(c) The US Army Corps of Engineers

(d) The Federal State Land Use Commission

(e) Geological Survey

(f) The Off-Base Facilities Section of Base Civil Engineering at Elmendorf

(g) Alaskan Air Command Headquarters Civil Engineering personnel.

B. Construction History - All of the airfield pavements were constructed during 1943 and 1944 under an accelerated wartime program. No design or construction documents for this early construction are available. The grading for Runway A was accomplished in 1943 by Military Engineer personnel. The fill sections were constructed with uniformly graded dune sand without compaction other than that obtained by the hauling equipment itself. Civilian contractors completed construction in 1944. All of the pavements were paved with approximately 5 inches of hot mix Asphaltic Concrete (AC). In 1950, the runway received a surface treatment. In 1961, the runway was rehabilitated. This work consisted of placing a 2-inch AC overlay keel strip 75 feet wide with 40 foot wide transition sections on each side of the keel. During the same construction period, the hangar number 2 access taxiway was lengthened, and the central portion of the transient parking apron was overlayed. Taxiway number 3 and the access aprons

to hangars 3 and 4 were rehabilitated during the 1962 and 1963 construction seasons. The rehabilitation consisted of the restablishment of taxiway grade with a crushed aggregate base course which was placed directly on the existing AC. A minimum of 3 inches of AC surfacing 60 feet wide was placed over the leveling layer. The shoulders were widened to 25 feet and stabilized with 2 inches of AC. The east portion of the transient parking apron was also overlayed with a minimum of 2 inches of AC. During 1965 construction season, taxiway number 3 and the access apron to hangar number 5 were overlayed with a minimum of 2 inches of AC. The 25 feet stabilized shoulders of taxiway number 2 were widened by 12 feet with 2 inches of AC. During the same construction season, a 150 foot wide section of taxiway number 1 was also overlayed with 2 inches of AC. During the winter of 1966, it became apparent that the surface grades of the runway had degraded to the extent that the surface control of aircraft at high speeds was becoming difficult. The high spots were remove with a heater-planer operation. During the following construct n season, longitudinal and transverse grades were reestablished b filling the low areas with 1 to 4 lifts of Asphaltic Concrete leveling courses 2 1/2 inches thick and the entire runway was then overlayed with 1 1/2 inches of AC. The hazardous Cargo Pa ing Apron Taxiway was levelled with 1 1/2 inch AC surface cours and Taxiway number 2 and portions of Taxiway number 3 and the Transient Parking Apron were overlayed with 1 1/2 inches of AC pavement.

C. The following is a summary of the opinions of personnel contacted in the Anchorage area. There was a general agreement that since the island slopes from north to south and the airfield was constructed generally east-west, the cause of subsidence under and near airfield pavements would be related to drainage. This includes man-made drainage facilities such as natural streams which were bridged with timbers and a fill section placed on top at the time of construction and/or natural drainage which was interrupted. The possibility that abandoned utility distribution lines may now be carrying water and subsurface fines was also cited as a possible course.

D. Subsurface Exploration Equipment

(1) Five void detection devices were considered. They were the three at US Army's Mobility Equipment Research and Development Center (MERDC) i.e., the Electromagentic Tunnel Detector, A Seismic Refractometer, and an Infrared Detector. The other two systems were a commercial version of one of the MERDC systems and the Electro-magnetic Subsurface Profiling equipment which was actually utilized. The Geophysical Survey System's Electromagnetic Subsurface Profiling equipment was selected as being the most appropriate system to utilize at Shemya AFS due to the extremely remote location of the island and the portability of electromagnetic subsurface profiling. It also offered the highest probability of success in the volcanic soils, was available for deployment and reasonably.

priced. A brief description of the ESP system follows.

(2) The Electromagnetic Subsurface Profiling equipment belonging to Geophysical Survey Systems, Inc. represents an advanced radar technology, involving video pulses, and operates as follows. A short video pulse, made up of low frequency radio waves is propogated through the overburden (vegetation, topsoil, pavement, etc.) into the substrata. Some of these pulses are reflected back and are recorded as a function of time. These refelctions occur primarily at the soil-bedrock interface and/or soil water interface and other anomolies. The baseline signal is reflected from the top of the ground or pavement at the pavement air interface. Based on a knowledge of the velocity of the electromagnetic signal in the soil medium, the time scale can be converted into a depth scale. At Shemya, the time scale was converted into a depth scale utilizing an anomoly of known depth. The system does have some limitations and are briefly described herein.

(a) The electrical conductivity of the soil is a limiting factor in the depth of penetration attainable.

(b) Pavements containing reinforcing steel will distort the reflected signal by producing a "ring-down".

(c) The presence of salt water will also interfere with penetration of signal.

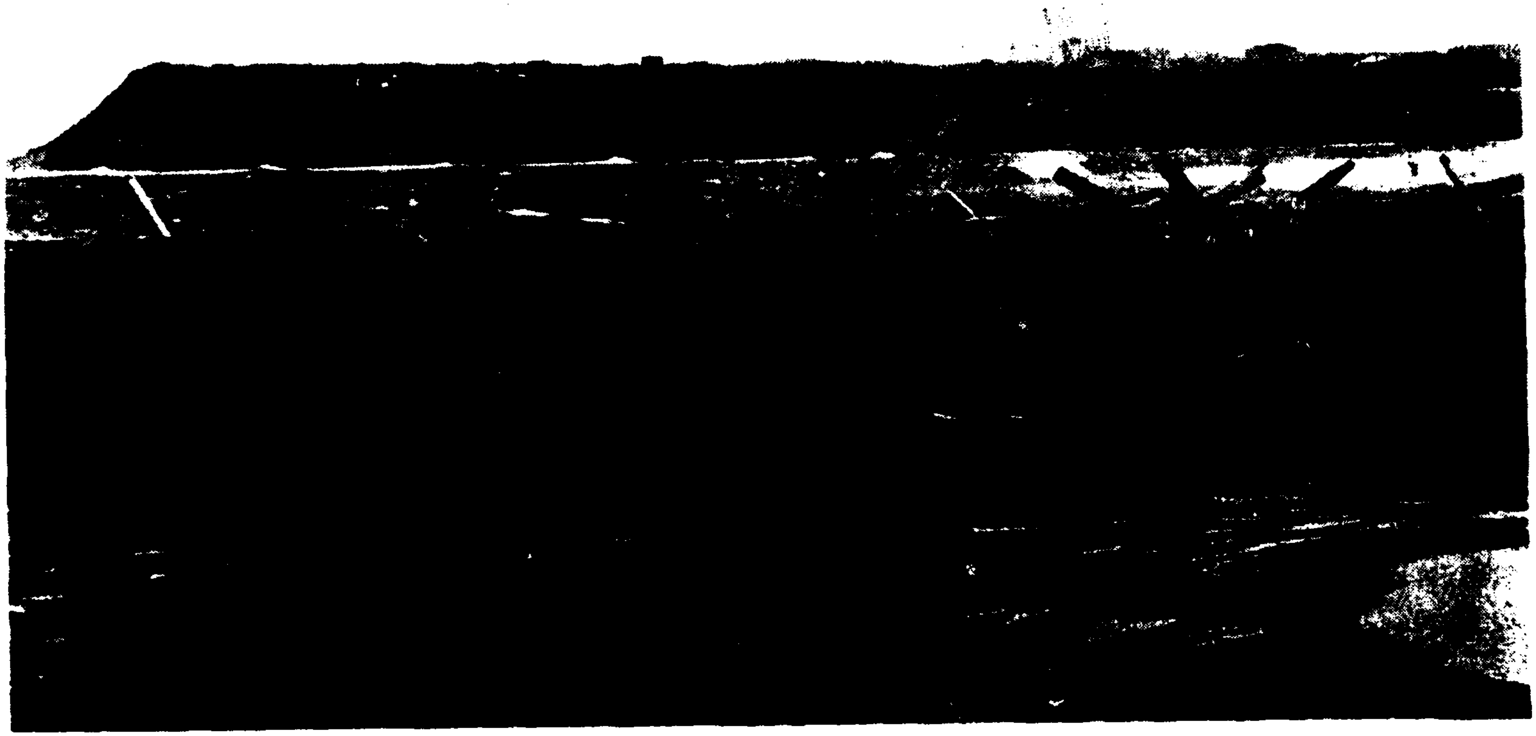
(d) A considerable amount of training is required in interpretation of the data printout. Technical details of the equipment can be found in the US Environmental Protection Agency Report No. EPA-R2-72-032 (October 1972).

E. The on-site study at Shemya was conducted 25 Jan 74 thru 1 Feb 74 with the first four days being utilized for visual inspection of rock formations, drainage patterns, and facilities, discussions with site personnel and familiarization with the pavement systems. The remaining time was spent utilizing the electromagnetic subsurface profiling equipment described in Section D. The enclosed drawing shows the profiling routes, as well as the location and estimated depths of subsurface culverts, cable crossings, metallic objects, and possible compressible layers. The plan also includes suggested drilling locations for proposed deep borings, when weather permits and equipment becomes available.

Quarry Near Main Site. View Showing Faulting.

Rock Quarry at East End of Ilsnad. NOTE: Tilting of Rock-Heave.

Fractured-Jointed Rock East End of Runway.

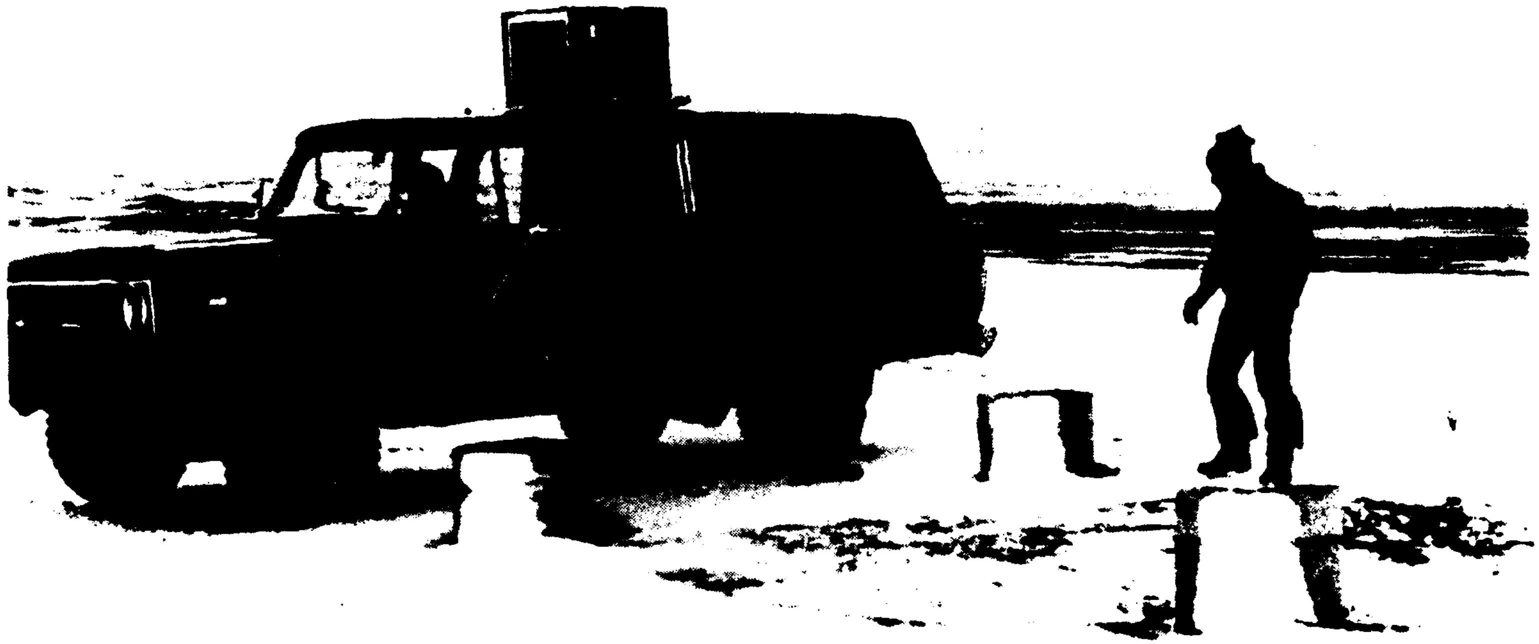


North End of Island. NOTE: Gentle Tilting Towards South.

Downstream End of Culvert Showing Water Borne Deposits Washed Out from Under Subsided Taxiway.

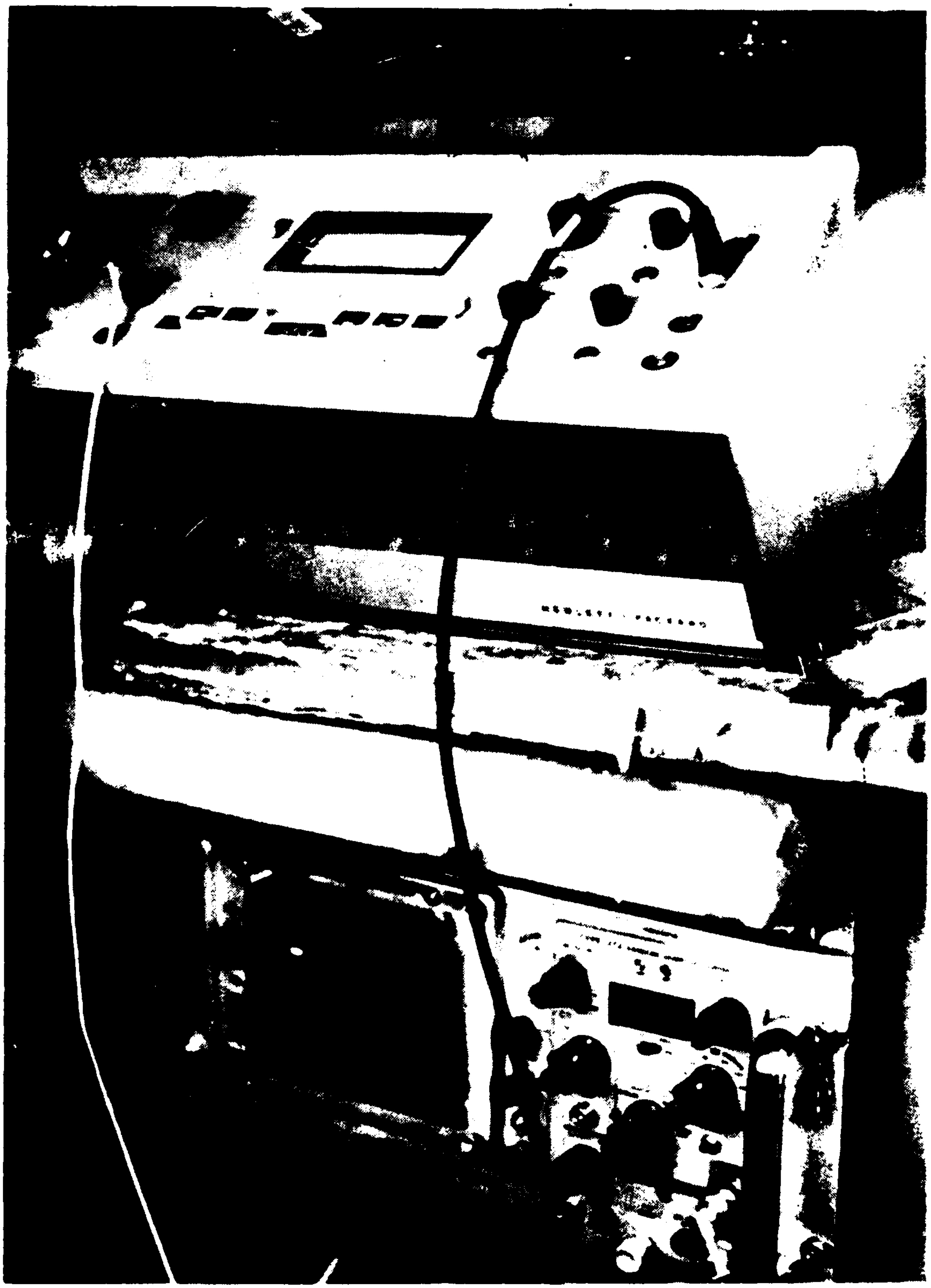
Downstream End of Culvert Showing Water Borne Deposits Washed Out from Under Subsided Taxiway.

ESP - Antenna Unit Being Towed Behind Truck Containing Equipment.

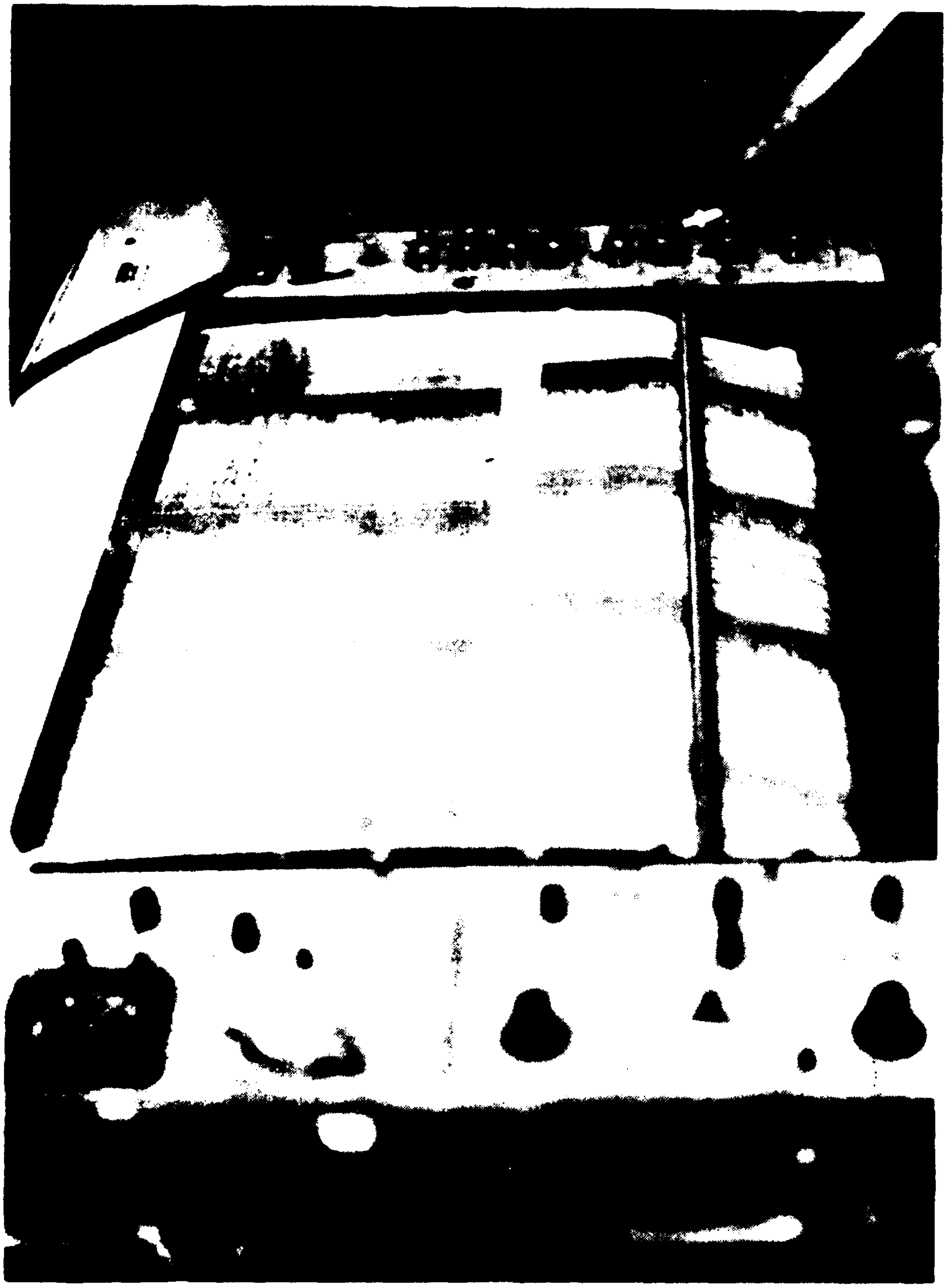


Traverse Over Subsidence.

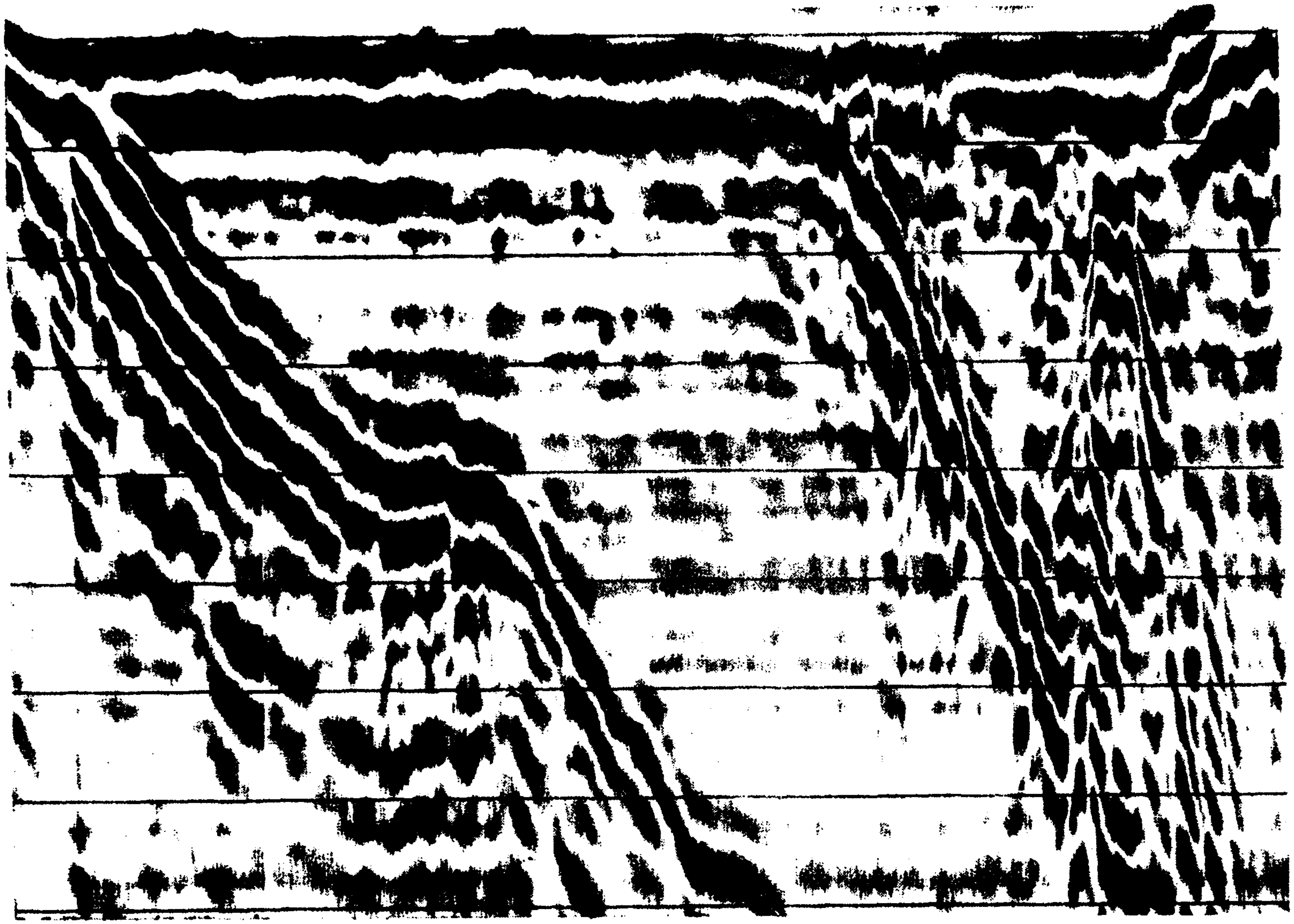
ESP Equipment.



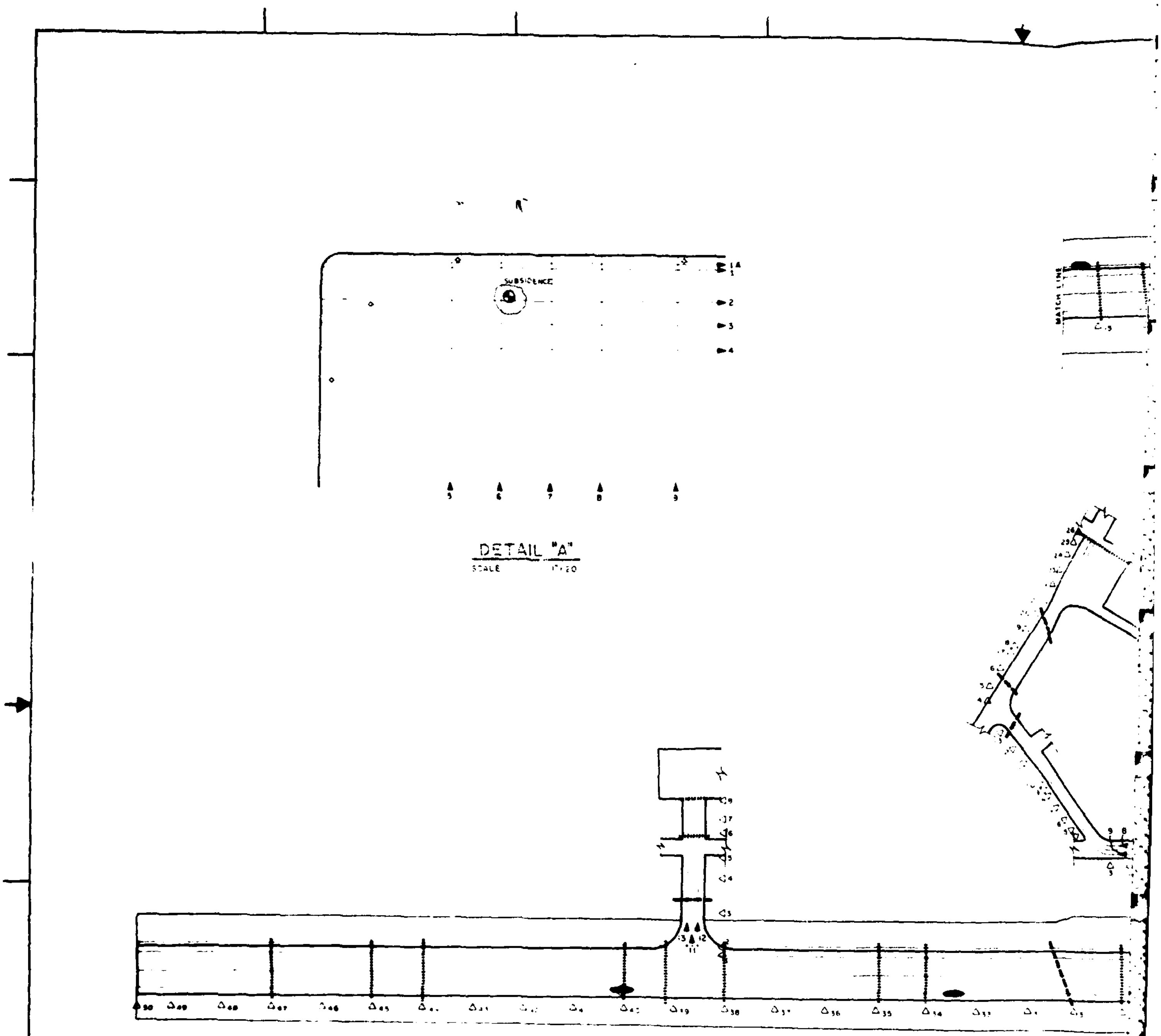
ESP - Recording Equipment.



ESP Printer



Sample of ESP Printout.

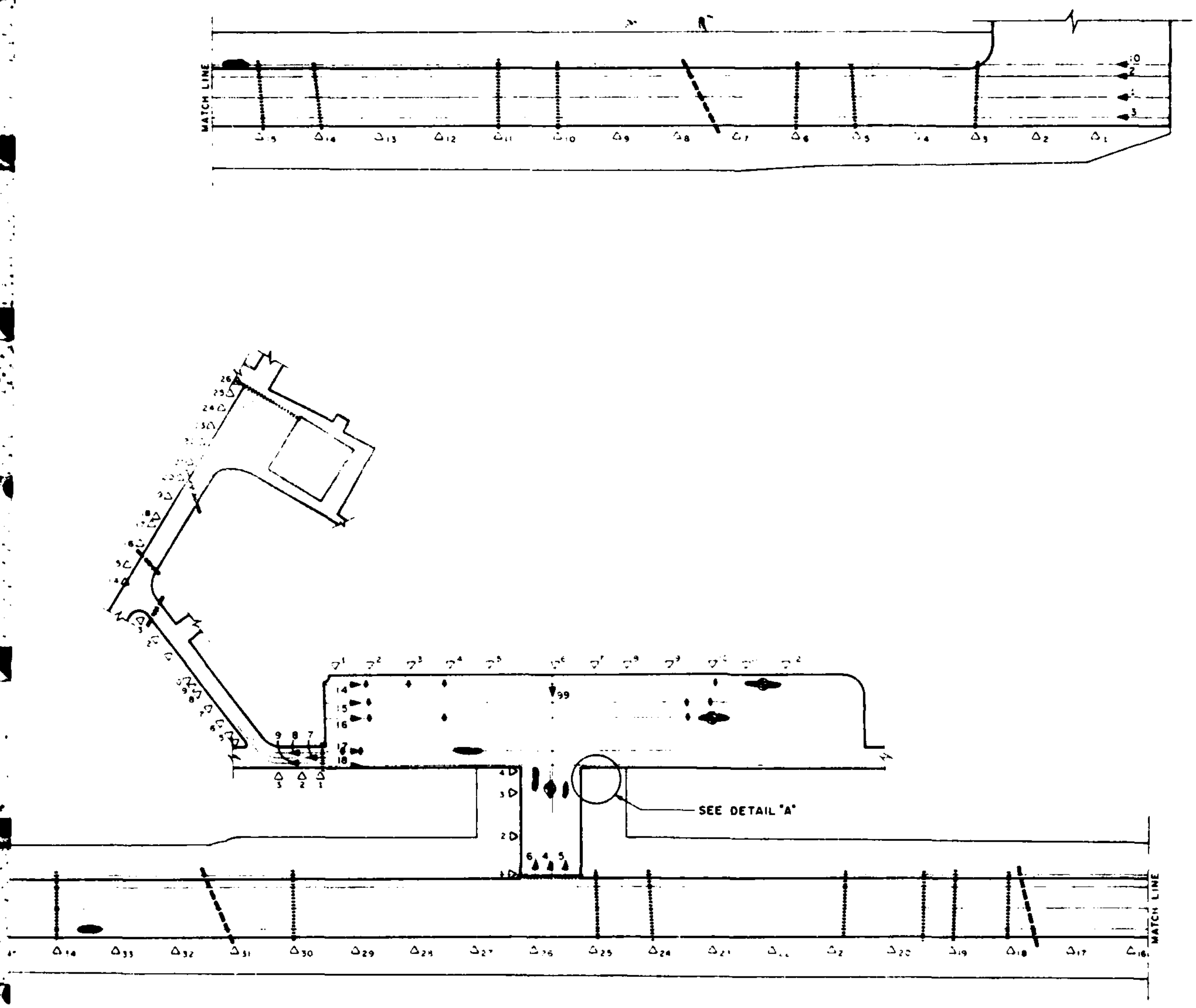


DEPTH TO BURIED OBJECT/LAYER			
FEATURE	REFERENCE POINT	RUN #	APPROXIMATE DEPTH (FT)
R/W	3	1-2-3-10	1 - 2
R/W	5	"	3
R/W	6	"	1 - 2
R/W	7 - 8	"	20 (+)
R/W	10	"	1 - 2
R/W	11	"	2 - 3
R/W	14	"	2 - 3
R/W	15	"	2 - 3
R/W	15 - 16	10	1
R/W	17 - 18	1-2-3-10	20 (+)
R/W	18	"	2 - 3
R/W	19	"	2 - 3
R/W	19 - 20	"	2 - 3
R/W	26	"	4
R/W	28	"	1 - 2
R/W	30	"	2 - 3
R/W	31 - 32	"	20 (+)
R/W	33 - 34	3	"
R/W	34	1-2-3-10	1 - 2
R/W	35	"	1 - 2
R/W	38	"	2 - 3
R/W	39	"	2 - 3
R/W	40	"	2 - 3
R/W	40	3	2 - 3
R/W	44	1-2-3-10	2 - 3
R/W	45	"	2 - 3
R/W	47	"	2 - 3

DEPTH TO BURIED OBJECT/LAYER			
FEATURE	REFERENCE POINT	RUN #	APPROXIMATE DEPTH (FT)
ACFT PARKING RAMP	1	17	5
"	2	14-15-16-17	3 - 4
"	3	14	5
"	4	14-16	5
"	4-5	17	3
"	9	15-16	3
"	10	14-15	4
"	10	16	3-4
"	11-12	14	4
T/W 1	1	4-5-6	1-2
T/W 1	3-4	4-5-6	3
T/W 2	3-4	11-12-13	10
	6	11-12-13	1-2
	8	11-12-13	1-2
T/W 3	1	7-8-9	1-2
	13	7-8-9	10-15
	16	7-8-9	10-15
	20	7-8-9	10-15
	26	7-8-9	1-2

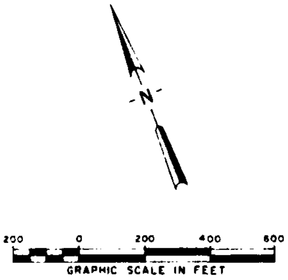
LEGEND

- RUN DIRECTION & NUMBER
- Δ_1 REFERENCE POINT & NUMBER
- SUSPECTED CULVERT
- SUSPECTED CABLE CROSSING
- METAL OBJECTS
- POSSIBLE COMPRESSIBLE LAYER
- SUGGESTED DRILLING LOCATIONS



LEGEND

- RUN DIRECTION & NUMBER
- REFERENCE POINT & NUMBER
- SUSPECTED CULVERT
- SUSPECTED CABLE CROSSING
- METAL OBJECTS
- POSSIBLE COMPRESSIBLE LAYER
- SUGGESTED DRILLING LOCATIONS



COORDINATION	
OFFICE	DATE

REV	DATE	DESCRIPTION	DRAWN	APPR'D

UNITED STATES AIR FORCE
CIVIL ENGINEERING CENTER
TYNDALL AIR FORCE BASE, FLORIDA

ELECTROMAGNETIC
SUBSURFACE PROFILING STUDY

SHEMYA AIR FORCE STATION, ALASKA

SUBMITTED	RECOMMENDED	APPROVED

DESIGNED	CHECKED CAPT B	SCALE GRAPHIC	PAGE 21
DRAWN LARSON	DATE FEB 74	PROJECT NUMBER	SHEET 1 OF 1

III. FINDINGS AND CONCLUSIONS

A. ESP shows great promise but it appears that it can only be utilized with confidence if borings or vertical cut is available for calibration of the time/depth scale.

B. At Shemya, the subsidence studies appears local in nature. Since the materials all around the subsidence have continuous interface with each other, the ananoly and resulting hole was probably due to the original construction tecniques. It appears that a coarse rock fill with fines was placed over the native rock and that water may now have carried the fines into the underlying rock matrix.

C. Minor sink holes could occur in any of the pavements constructed with dune sand fill placed over in-place shattered rock subgrade.

D. Fine graned soils with little or no plasticity will flow or be carried by water through very small openings such as those created by nontight pipe joints or spaces in wooden culverts. Typical results of this action can be seen in photos in Section E.

IV. RECOMMENDATIONS

A. Drilling be accomplished at Shemya according to the drilling plan provided in Section ..

B. Culverts located by the ESP equipment should be visually inspected.

C. That backfilled subsidence be monitored, especially after heavy rains or snow melt.

D. That any future use of the ESP equipment include drilling or exposing a vertical cut so that the time/depth scale of the printout can be established.

END

FILMED

2-83

DTIC